Phytoparasitic Nematodes Adjacent to Established Strawberry Plantations[1]

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Abstract: Plant-nematode populations associated with uncultivated vegetation, adjacent strawberry plants, and alternate crop sites were studied at three locations in Minnesota. At one site (Forest Lake), *Paratylenchus projectus, Meloidogyne hapla,* and *Pratylenchus tenuis* were frequently associated with the roots of native vegetation. These nematode species were also present in adjacent strawberry beds. Among alternate crops observed, oats and muskmelon usually supported the fewest nematodes although moderate densities of *Xiphinema americanum* and *P. tenuis* were found at one location in plots planted to oats. *Pratylenchus tenuis* was also found on rye at one location. *Key Words:* Population dynamics, control, nonhost plants, *Meloidogyne hapla, Paratylenchus* sp.

Plant-parasitic nematodes in cultivated soil may be affected by the planting of cover crops, the use of alternate crop sequences, and fallow (1, 2, 3, 5). Cover crops can influence plant-nematode densities in newly cleared and old agricultural land (1, 2). Investigations with alternate cropping and short-term (6 weeks) fallow indicate that nematodes may be controlled better by a combination of the two practices than by either alone (3, 5).

Morgan and Collins (8) observed that densities of *Pratylenchus penetrans* were low in strawberry plantings if favorable weed hosts were removed. In a host range study, 55 species of weeds and 7 cultivated plant species growing near strawberry were infected by *P. penetrans* (9). Weeds with soft-textured roots contained more nematodes than those with hard-textured roots, and perennials supported higher nematode populations than did annuals. Townshend and Davidson (9) suggested that *P. penetrans* probably overwintered in weeds with soft-textured roots.

Soil and root samples from wild strawberry plants *(Fragaria virginiana)* in wooded areas in Maryland contained *Helicotylenchus dihystera, P. penetrans, Xiphinema* sp., *Meloidogyne hapla, Tylenchorhynchus* sp., *Hoplolaimus* sp., and *Paratylenchus* sp. These genera are also frequently found in commercial strawberry plantings. Such findings suggest the possibility that nematodes found in strawberry plantings could be indigenous to the soil (4).

Because of the obligate parasitism of plant-parasitic nematodes, the use of host and nonhost plants often results in striking changes in nematode populations. Such changes were studied in, and adjacent to, established strawberry plantings at three locations in Minnesota.

MATERIALS AND METHODS

Soil samples, each consisting of 5-8 cores (2.5 x 25 cm) composited in a plastic bag, were collected from strawberry beds and contiguous areas. The number of samples taken from a strawberry bed depended upon the bed length. Three samples were collected from beds 15 to 46 m long while five samples were taken from beds up to 153 m long. Fields or groves were sampled according to total area. Twelve samples were collected from a 0.2- to 0.5-ha area, whereas 20 samples were taken from a 1-ha field. The sampling techniques employed utilized the recommendations of Langdon (7). An

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attempt was made to collect a representative but manageable number of samples. From each sample of soil, two 50-cm^3 subsamples were processed by the Cornell piepan method, a modified Baermann funnel technique (6). Nematodes extracted during a 3- to 7-day period were identified and counted.

Soil was collected from uncultivated plots of native vegetation, cultivated crop sites adjacent to established strawberry beds, and strawberries *(Fragaria ananassa)* at Forest Lake, Cottage Grove, and Detroit Lakes, Minnesota. At Forest Lake, oats *(Avena sativa)*, rye (*Secale* sp.), and corn *(Zea mays)* were grown in addition to several cultivars of strawberry ('Vee Star', 'Badgerbelle', 'Red Coat', and 'Trumpeter'). Uncultivated areas (fence rows and borders) contained sumac (*Rhus* sp.), plum (*Prunus* sp.), and various species of grass and broadleaved plants. Approximately 5 years previously, the entire cultivated area had been planted in corn and soybeans *(Glycine max)*. The Detroit Lakes location had been cultivated for about 10 years, the land having been cleared from a forest. At the Detroit Lakes site, rye was grown as an alternate crop with strawberry. Adjacent uncultivated areas were wooded and contained several species of trees including aspen (*Populus* sp.), birch (*Betula* sp.), oak (*Quercus* sp.), juniper (*Juniperus* sp.), spruce (*Picea* sp.), and pine (*Pinus* sp.). The third location, Cottage Grove, had been under cultivation for approximately 23 years. A rotation sequence of strawberry, corn, and muskmelon *(Cucumis melo)* had been followed during that time. Separate plots of raspberry (*Rubus* sp.) were also maintained. Uncultivated areas consisted of red pine *(Pinus resinosa)* and American elm *(Ulmus americana)* which were planted between 1940 and 1950.

RESULTS AND DISCUSSION

At Forest Lake, uncultivated areas supported large populations of *Meloidogyne hapla* (x = 519/100 cm^3 of soil) and *Paratylenchus projectus* (x = 450/100 cm^3 of soil). Moderate densities of *Pratylenchus tenuis* (x = 37/100 cm^3 of soil) and *Xiphinema americanum* (x = 32/100 cm^3 of soil) were also isolated from these plots of native vegetation. Corn, rye, and first-year strawberry plantings supported reproduction of *P. projectus*. Rye and first-year strawberry plants favored the survival and reproduction of *P. tenuis* and *M. hapla*, respectively. Appreciable differences in numbers of *P. projectus* and *P. tenuis* were observed between adjacent plantings of rye and second-year strawberry beds (Table 1).

TABLE 1. Effects of strawberries and alternate crops on indigenous nematode populations at Forest Lake, Minnesota.

Adjacent areas sampled	Mean number of nematodes/100 cm^3 of soil (3 samples/area)[a] Mh	Par	Pt	Xa	Ty
Area 1					
Uncultivated vegetation (weeds, grass & sumac)	519	450	37	32	0
Oats	7	37	68	5	0
Strawberry (1 year)	368	141	35	2	21
Area 2					
Corn	0	186	2	25	0
Oats (1 year previously strawberry)	10	49	0	70	0
Strawberry (2 years)	0	14	23	17	0
Rye	0	116	233	0	0

[a]Mh = *Meloidogyne hapla*, Par = *Paratylenchus projectus*, Pt = *Pratylenchus tenuis*, Xa = *Xiphinema americanum*, Ty = *Tylenchorhynchus* sp.

Paratylenchus projectus and *X. americanum* were the predominant nematode species found in uncultivated windbreaks adjacent to strawberry beds at Cottage Grove (Table 2). In Area 3 of this location, the relatively large numbers of *X. americanum* observed in established raspberry plots were not present in adjacent soils of an uncultivated windbreak and a second-year strawberry planting (Table 2). In each of the three areas at Cottage Grove, strawberry, raspberry, and muskmelon plantings appeared to have a negative effect upon densities of *P. projectus* (Table 2). Populations of *Helicotylenchus pseudorobustus* were isolated from the soil of second-year strawberry (x = 94/100 cm^3 of soil) and from fallowed land previously planted to strawberry (x = 93/100 cm^3 of soil) in Area 3.

Wooded areas adjacent to strawberry plantings in Detroit Lakes yielded small numbers of *Paratylenchus* sp., whereas soil

TABLE 2. Nematodes associated with strawberries, alternate crops, and adjacent windbreaks at Cottage Grove, Minnesota.

Adjacent area sampled	Mean nematodes/100 cm^3 of soil (3 samples/area)[a]			
	Mh	Par	Ps	Xa
Area 1				
Uncultivated windbreak	0	34	0	19
Strawberry (3 years)	0	3	0	0
Area 2				
Uncultivated windbreak	0	70	0	61
Strawberry (1 year previously in corn)	0	10	0	0
Fallow (previously in strawberry)	60	154	0	2
Uncultivated windbreak	0	402	0	37
Raspberry	0	6	13	22
Muskmelon	0	32	0	3
Uncultivated windbreak	0	28	0	21
Area 3				
Strawberry (2 years previously in corn)	2	0	4	6
Uncultivated windbreak	0	10	0	0
Strawberry (2 years previously in corn)	156	6	0	25
Windbreak	0	158	0	69
Raspberry	0	0	6	150
Windbreak	0	31	0	5
Fallow (previously in strawberry)	5	0	16	0

[a]Mh = *Meloidogyne hapla*, Par = *Paratylenchus projectus*, Ps = *Pratylenchus scribneri*, Xa = *Xiphinema americanum*.

TABLE 3. Nematodes associated with strawberries, alternate crops, and adjacent wooded areas at Detroit Lakes, Minnesota.

Area Sampled	Mean nematodes/100 cm^3 of soil (3 samples/area)[a]			
	Mh	Par	Pc	Xa
Rye (1 year previously strawberry)	19	0	6	0
Wooded area (uncultivated)	0	8	0	0
Strawberry (2-3 years)	98	4	28	0
Wooded area (uncultivated)	0	0	0	0
Rye (1 year previously strawberry)	0	0	0	0
Wooded area (uncultivated)	0	0	0	0
Strawberry (1 year)	0	0	0	0
Wooded area (uncultivated)	0	2	0	4

[a]Mh = *Meloidogyne hapla*, Par = *Paratylenchus* sp., Pc = *Pratylenchus coffeae*, Xa = *Xiphinema americanum*.

from strawberry beds contained primarily *M. hapla*. Rye in plots previously planted to strawberry supported small populations of *M. hapla* and *Pratylenchus coffeae* (Table 3). An area of poorly growing strawberries, sampled in September 1971, contained a mean of 1,154 *M. hapla*/100 cm^3 of soil. In 1973, following destruction of the strawberry plants, incorporation of rye into the soil, and a clean-fallow period, this location was sampled again. The average number of *M. hapla* had declined to 34/100 cm^3 of soil.

Meloidogyne hapla, Paratylenchus spp. and *X. americanum* can be found in large numbers in uncultivated areas of native vegetation in Minnesota. The nematodes are most likely indigenous there and it is possible that such areas serve as overwintering reservoirs and sources of inoculum. These findings are in agreement with those of others who have studied different nematode genera from other geographical areas (4, 9).

In adjacent plots of Area 1 at Forest Lake, (Table 1) the large populations of *P. projectus* and *M. hapla* found in uncultivated vegetation and 1-year-old strawberry beds became absent after about 8 months of clean fallow were followed by 4 months in which the dominant plants were oats. Numbers of *Pratylenchus tenuis* and *Xiphinema americanum* were slightly increased in the oat plantings, however. Data from adjacent plots of 2-year-old strawberry and rye in Area 2 at Forest Lake indicate that rye would be a poor selection as an alternate crop for the control of *Paratylenchus* and *Pratylenchus* because their numbers increased substantially in the rye plantings. These results demonstrate the importance for Minnesota growers of being familiar with the kinds and densities of plant-parasitic nematodes in soil and how cultural practices affect them.

Increases in nematode numbers with the increasing age of strawberry beds were observed at two locations. In Cottage Grove, a 2-year-old strawberry bed contained large numbers of *M. hapla* (Table 2). A second 2- to 3-year-old bed at Detroit Lakes also contained greater numbers of *M. hapla* than did a younger bed (Table 3). In contrast, however, 2- and 3-year-old strawberry beds also contained negligible densities of

M. hapla (Table 2), but at Forest Lake, a first-year bed contained a mean of 368 *M. hapla*/100 cm^3 of soil. These results suggest that avoidance of infected planting stock is important in control of plant-parasitic nematodes. Also, there is a need for inspection of strawberry nursery stock in northern states where nematodes were previously not considered to be widespread and of economic significance.

Strawberry beds, after being destroyed and placed in clean fallow (following 2-3 crops) for 2-3 months contained relatively high numbers of *M. hapla, Paratylenchus,* and/or *Helicotylenchus* species (Table 2). A somewhat longer fallow period, perhaps 8-10 months, appears to be necessary for greater and economically significant reductions of these nematode populations.

Many growers have developed cultural practices which, as shown by this work, tend to reduce or minimize the potential growth of indigenous and introduced plant parasitic nematodes on strawberry. Other important factors such as soil type and cultural practices need to be considered before the complete role of these nematodes in strawberry plantings is understood.

LITERATURE CITED

1. BRODIE, B. B., J. M. GOOD, and C. A. JAWORSKI. 1970. Population dynamics of plant nematodes in cultivated soil: Effect of summer cover crops in old agricultural land. J. Nematol. 2:147-151.
2. BRODIE, B. B., J. M. GOOD, and C. A. JAWORSKI. 1970. Population dynamics of plant nematodes in cultivated soil: Effect of summer cover crops in newly cleared land. J. Nematol. 2:217-222.
3. BRODIE, B. B., and W. S. MURPHY. 1975. Population dynamics of plant nematodes as affected by combinations of fallow and cropping sequence. J. Nematol. 7:91-92.
4. GOHEEN, A. C., and A. J. BRAUN. 1956. Some parasitic nematodes associated with wild strawberry plants in woodlands in Maryland. Plant Dis. Rep. 40:43.
5. GOOD, J. M., W. S. MURPHY, and B. B. BRODIE. 1973. Population dynamics of plant nematodes in cultivated soil: Length of rotation in newly cleared and old agricultural land. J. Nematol. 5:117-122.
6. KABLE, P. F., and W. F. MAI. 1968. Influence of soil moisture on Pratylenchus penetrans. Nemotologica. 14:101-122.
7. LANGDON, K. R. 1963. Procedures for determining numbers of soil samples to be taken in various survey and certification inspection situations. Florida Dept. Agric. Div. Plant Industry Mimeo., N-50. 4 p.
8. MORGAN, G. T., and W. B. COLLINS. 1964. The effects of organic treatments and crop rotation on soil populations of Pratylenchus penetrans in strawberry culture. Can. J. Plant Sci. 44:272-275.
9. TOWNSHEND, J. L., and T. R. DAVIDSON. 1960. Some weed hosts of Pratylenchus penetrans in Premier strawberry plantations. Can. J. Bot. 38:267-273.